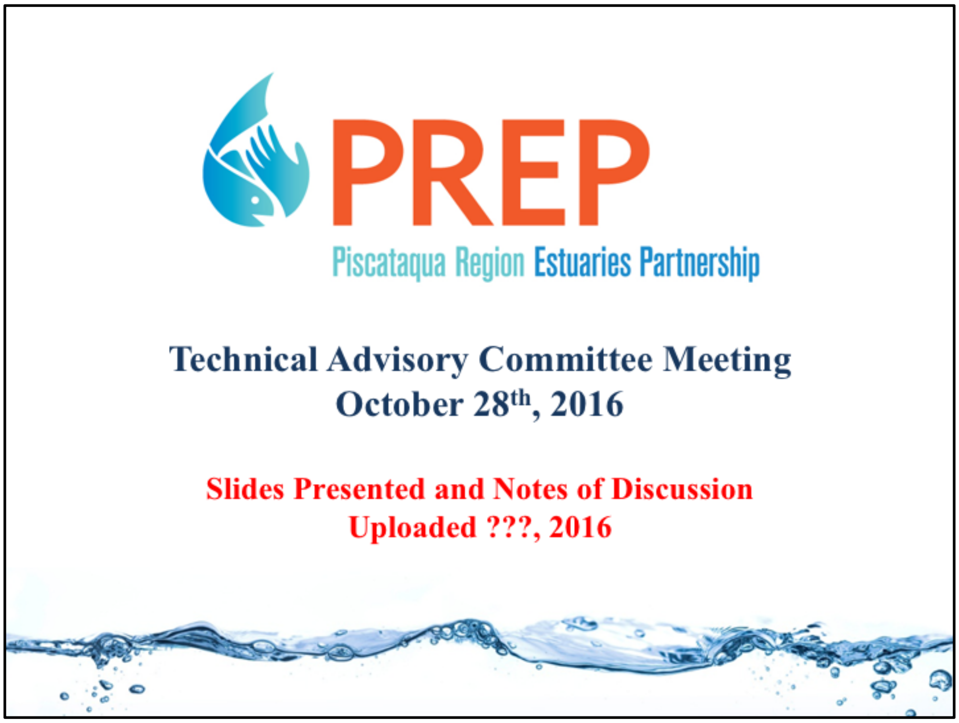

List of Attendees

Paul Stacey, Phil Colarusso, Toby Stover, Dan Arsenault, John Storer, Michael Bezanson, Jeff Barnum, Alison Watts, Matt Wood, Rich Langan, David Patrick, David Burdick, Ted Diers, Dean Peschel, Steve Jones, Lindsey Williams, Jud Kenworthy, Semme Dijkstra, Ashley Norton, Fred Short, Brian Giles, Rob Roseen, Art Mathieson, Cory Riley, Ken Edwardson, Terry Delmaraic, Ru Morrison, Dave Patrick, Jennifer Dijkstra

And PREP Staff: Rachel Rouillard, Kalle Matso, Abigail Lyon, Jill Farrell and Simone Barley-Greenfield

About These Notes

Readers will feel at times as though these notes are verbatim from the meeting. They should not be considered verbatim. Rather, we attempted to make the notes more conversational for readability. Please do not quote these notes as though it is a verbatim transcript.

Sometimes, when PREP staff are not sure about name of the speaker, we will list the person more generically as “Committee Member.”

Rachel Rouillard (exec director, PREP): The first TAC meeting was a very productive way to get started. Want to continue this strategic discussion about the indicators before we talk about how they are connected.

Kalle Matso (coastal scientist, PREP): Today, we have an external member of the TAC for the first time. I’d like to introduce Jud Kenworthy. Jud, can you introduce yourself?

Jud: Retired from NOAA, 33 years at the coastal lab in North Carolina, Center for Coastal Fisheries and Habitat...worked with scientists looking at the use of seagrass habitat. My specialty has been in habitat and vegetation. I was invited by Phil Trowbridge to be part of a Peer Review panel in 2014, and I’ve since done follow up work with NH DES and PREP.

Kalle: Jud was one of 4 reviewers brought on for the peer review (2014). Another was Vic Bierman (lead), and we’ve been chatting with Vic as well.

Today, I’ll frequently be referring to the Eelgrass and Macroalgae Primer, written by me, which is available on the TAC webpage.

Our overall process with these indicators is that we will start with talking about what was done in the last data report (to download, please see: http://scholars.unh.edu/prep/265/), then, as part of the second iteration, we’ll provide some draft figures and language, and we’ll continue to check with the TAC to get suggestions on how to move forward.

Today we are talking about macroalgae and eelgrass and we will continue to stagger through. Remember that we are here to learn and not set policy. Whatever we say in here, people are going to try and argue their ideas about policy. We don’t have control over that, but we are focused on the science.

Today's Topics

- Eelgrass
  - Biomass, 1996
  - Our interpretation of the Peer Review with regard to nitrogen and eelgrass
  - Epiphytes
  - Review of eelgrass graphs from 2012 Data Report
- Subtidal Macroalgae and SeagrassNet
- Intertidal Macroalgae: potential ways of showing data

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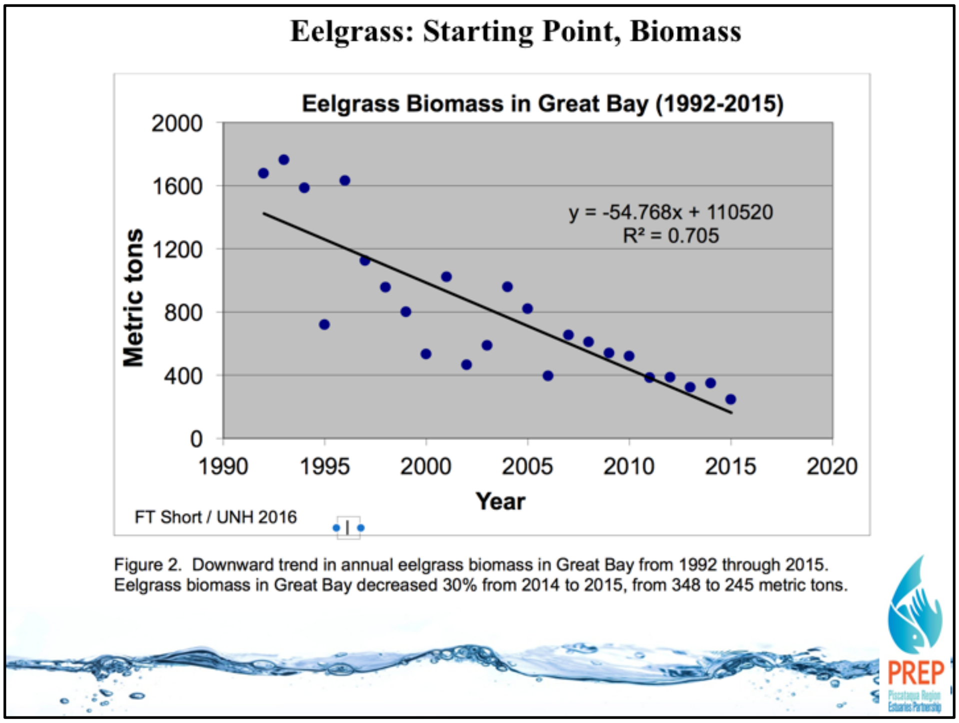
Kalle:

Again, there's a lot on these topics in the primer I mentioned, which an be accessed at: http://scholars.unh.edu/prep/355/

- We'll start off talking about biomass, as opposed to percent cover. It's an important parameter, but wasn't in the last data report.
- Then, we'll talk about why, in these discussions, we often mention the year 1996 as a reference point.
- I want to spend some time talking about the Peer Review.
- We'll also discuss epiphytes.
- We'll review the eelgrass graphs from 2012 data report.
- Then talk about subtidal macroalgae and finally intertidal macroalgae and potential ways of showing the data we have on that.



Kalle: This graph comes from the latest "Eelgrass Distribution Report: 2015," which you can access at: http://scholars.unh.edu/prep/354/

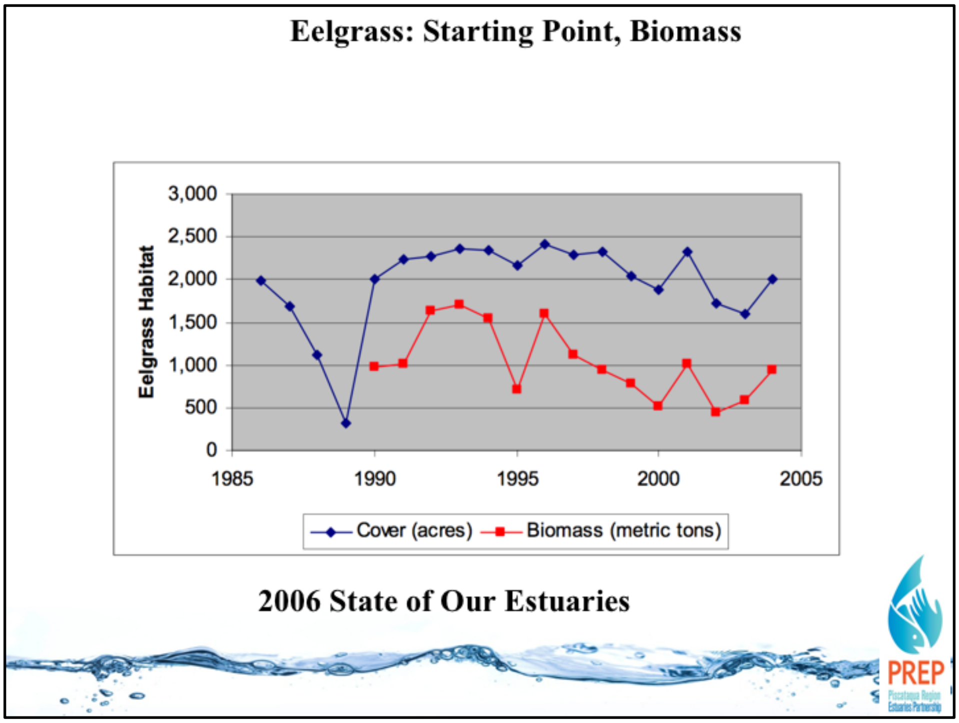
This report was put together by Fred Short, as were many of the previous reports.

Most of the report is about percent cover; this graph is about biomass. When we talk about percent cover, we are just asking where in the Great Bay Estuary do we have eelgrass. If there's less than 10% we don't even consider it there. Biomass, on the other hand, tells us how dense and tall the eelgrass beds are and it tells us something about the root systems under the sediment. In other words, you could have eelgrass stay in all the same areas, but drastically change in biomass, and that would be important to know because the ability of eelgrass to provide ecosystem services relates to its biomass.

Are there any questions before we get into how these data points were arrived at?

Fred Short: Just want to point out that this graph is about Great Bay proper, as opposed to the whole Estuary. I don't estimate biomass for the whole Estuary for reasons I'll explain in a moment. This graph is telling you how much all the eelgrass in the Great Bay would weigh, in metric tons.

Jud: While biomass is a useful indicator, it doesn't provide as much information on the mechanics that impact biomass as well as other functions of eelgrass. Shoot density, since it is more closely tied to reproduction, reveals more about the mechanics. Also, it's important to point out that this chart reports on aboveground biomass, not what's going on below ground. Finally, biomass doesn't actually say anything about the how tall the eelgrass blades are.



Kalle: This graph is from the 2006 State of Our Estuaries report, and shows both percent cover and biomass.

Fred: It's important to note that these are on the same scale but have different units. Blue is area (acreage) and the red is the biomass similar to the previous plot. The low point in the blue (1989) was an outbreak of the wasting disease, and you can see that eelgrass quickly rebounded after that. That recovery came primarily from seed production. You can see that there was a major change in the area of grass, but the biomass didn't recover as fast.

Committee Member Question: In 1995, biomass has a big dip; was that for any particular reason?

Fred: I'm not sure why that happened. I think it may have been an unusually dark and rainy summer perhaps.

(Note: After the meeting, I looked at older reports and they indicated that "wasting disease" was, in fact, partially responsible for losses in 1995. Kalle)

Kalle: Fred, can you tell us how you know it wasn't wasting disease?

Fred: Wasting disease is identified by very clear brown/black spots on the leaves. David Burdick and I developed in index for tracking wasting disease and it's something I do every year as part of my assessments annually. The organism that causes wasting disease is always around, but in 1989 it was a lot more effective at impacting the plants.

Jud: Would suggest that this graph have two Y axes.

Eelgrass: Starting Point, Biomass

"In addition to mapping eelgrass bed boundaries, each eelgrass bed was assigned a density based on visual observation: partial (10-30% cover), half (30-60% cover), some bottom (60-90% cover) and dense (90-100% cover) (UNH, 2010). The ArcGIS Identity tool was used to calculate the area of eelgrass coverage in each density class in the different sections of the Great Bay Estuary. The biomass of eelgrass was calculated by assuming a shoot density for each density class: partial (25 g/m2); half (55 g/m2); some bottom (85 g/m2); and dense (250 g/m2). The total area of eelgrass in each density class was multiplied by the shoot density for the class to calculate the biomass for that class. The total biomass (in units of metric tons or 1000 kilograms) was calculated by summing the biomass from each density class of eelgrass."

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Kalle: This slide offers information on the methods behind the biomass calculation; it's taken from page 238 of the 2013 Data Report. Fred, can you tell us about these different cover classes and how you assign a density to them?

Fred: Percent cover is determined on a 1 to 100% scale. When I'm groundtruthing the aerial imagery, I go out in a boat and I pick four spots around the boat, each spot around 5 square meters. I give each one a number between 1 and 100 and then I average the four numbers for one percent cover number. As you see in description on the slide, these numbers then fit into categories: partial, half, some bottom and dense.

Kalle: How do you then convert that to density?

Fred: That description is actually a bit misleading. Let me give you the background. Phil Trowbridge and I wanted a way to look at what percent cover numbers meant in terms of how much eelgrass was out there. Percent cover is a good measure of how much grass is where, but you can't average them. They are specific to a location. Mathematically you can't combine them. So, we went back through work done in the Great Bay proper where I'd measured both cover and biomass—this based on measurements made in the late 80s and early 90s—and created conversion factors that would create these categories. So, 10-30% were 25g/m2 and so on as you see on the slide. in 2006/07 the highest density found was 250g/m2. Last year, with the help of EPA we sampled biomass and estimated cover again and the relationship nearly fit the same line. The main difference was, at the high end, we didn't find anything that was 250g/m2; the densest grass now has much less biomass.

Committee member comment: I'm concerned that this method assumes that all shoots weigh the same.

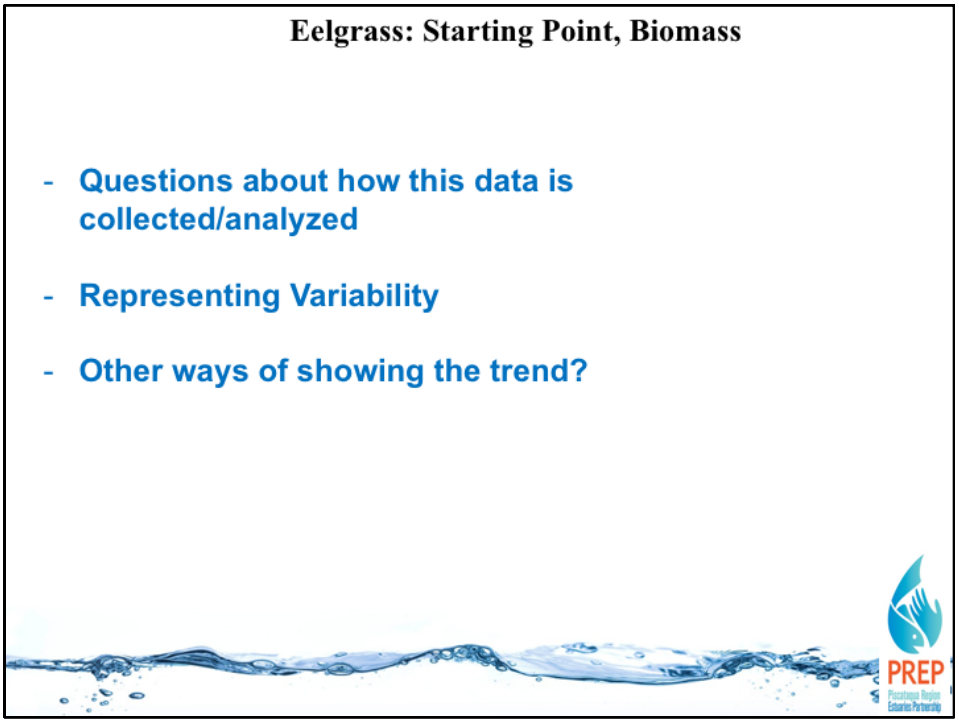
Fred: Actually, it's more about relating percent cover to biomass ranges. The variation in the different shoot weights is covered in the assessment of the categories.

Kalle: Jud…your thoughts?

Jud: There are a number of programs that have done similar types of conversions, based on the same principal. Some do the individual shoot comparison; what Fred has done is collectively combine the shoots in a particular category.

Committee member comment: Still have concerns that taller plants may, in fact, having lower densities.

Fred: That's true. Using SeagrassNet, we could do an intercomparison of different ways of relating percent cover to biomass.



Kalle: OK. I realize there are questions about biomass, but I'm recommending that we try to include this parameter in the State of Our Estuaries report. Are there other questions/comments having to do with the question up on the slide? Or other questions?

Committee Member: Fred…did you also do your conversion for eelgrass beds in the Piscataqua River or Portsmouth Harbor?

Fred: They're too different. In Portsmouth Harbor, the dense category, for example, goes up to 400 g/m2, as compared with 250 from Great Bay proper. If I used those data, it would skew the data and the relationship wouldn't be as tight.

Committee Member: Does this change a lot from year to year?

Fred: It's worth looking into if we had more money. Working with EPA, I did re-test the relationship and the new and old conversion factors are within 5% of each other.

Committee Member: I would advise a more expanded explanation for the value of this information. I believe the thinking is that, if you restrict yourself to presence/absence, by the time you get a change it's too late to change the management action. It's important to always be looking for early indication of problems. Anything that we can do to advance warning I would advocate should be used.

Committee Member: You've asked us if the data should be include. I'm curious about what our standard would be for not including data. Really important to consider. There are strong guidelines that we could look at or consider from NSF in terms of how to handle that.

Committee Member: One measure is if the data has been peer reviewed and/or published in a journal.

Jud: One thing that the TAC should consider is what you can do with the data. In other words, you are discussing if you should put it in, but what you want data to do is tell you something about processes or mechanisms within the system. The data should be useful in that context. Shouldn't just be a display of what's going on. Idea is to put out information that everyone in this room and the public can look at and get some idea of what's going on. Not just an illustration of a decline in biomass. That's a critical aspect of how you decide what to and what not to include.

Kalle: Thanks. We have to move on so I'd like to take a straw poll of the group. The recommendation is to include biomass in the SOOE report and that we'll address the concerns that we heard today. Voting results:

- Support = 15
- Support with reservations = 9
- Abstain = 4
- Block = 4

Thanks. Those of you had reservations, please write those down or email them to me.

Eelgrass: Graphs from Last Data Report

Table HAB2-1: Eelgrass coverage in the Great Bay Estuary

Year	Winnicut River	Squamscott River	Lamprey River	Oyster River	Bellamy River	Great Bay	Little Bay	Upper Piscataqua River*	Lower Piscataqua River North*	Lower Piscataqua River South*	Portsmouth Harbor*	Little Harbor	Sagamore Creek	Total
1981	0.0	0.0	0.0	a	3.4	2130.7	252.0	0.5	60.1	5.1	227.7	68.8	4.1	2752.3
1986	2.2	0.0	0.0	a	a	2015.2	a	a	a	a	a	a	a	
1987	2.2	0.0	0.0	a	a	1685.7	a	a	a	a	a	a	a	
1988	0.0	0.0	0.0	a	a	1187.5	a	a	a	a	a	a	a	
1989	0.0	0.0	0.0	a	a	312.6	a	a	a	a	a	a	a	
1990	15.9	0.0	0.0	a	a	2024.2	a	a	a	a	a	a	a	
1991	23.4	0.0	0.0	a	a	2255.8	a	a	a	a	a	a	a	
1992	7.3	0.0	0.0	a	a	2334.4	a	a	a	a	a	a	a	
1993	6.9	0.0	0.0	a	a	2444.9	a	a	a	a	a	a	a	
1994	13.8	0.0	0.0	a	a	2434.3	a	a	a	a	a	a	a	
1995	7.8	0.0	0.0	a	a	2224.9	a	a	a	a	a	a	a	
1996	7.6	0.0	0.0	14.0	0.0	2495.4	32.7	1.6	20.9	10.2	245.6	70.1	1.8	2900.0
1997	7.5	0.0	0.0	a	a	2297.8	a	a	a	a	a	a	a	
1998	10.0	0.0	0.0	a	a	2387.8	a	a	a	a	a	a	a	
1999	10.2	0.0	0.0	0.0	0.0	2119.5	26.2	0.5	7.4	4.0	244.0	50.1	3.0	2464.9
2000	0.0	0.0	0.0	0.0	0.0	1944.5	7.5	1.6	3.8	7.6	260.5	60.9	0.9	2287.3
2001	4.1	0.0	0.0	0.0	0.0	2388.2	10.9	2.0	9.7	10.7	274.2	45.3	2.2	2747.3
2002	3.5	0.0	0.0	0.0	0.0	1791.8	4.3	0.5	8.0	9.3	268.9	63.1	2.3	2151.7
2003	3.5	0.0	2.2	0.0	0.0	1620.9	14.2	2.9	22.9	9.2	270.1	54.7	2.2	2002.8
2004	4.2	0.0	0.0	0.0	0.8	2037.6	12.8	0.7	13.5	6.5	225.2	65.8	2.5	2369.8
2005	9.1	0.0	0.0	0.0	0.0	2165.7	25.8	0.4	14.5	9.6	232.5	47.9	6.1	2511.7
2006	0.8	0.0	0.0	0.0	0.0	1319.8	12.2	0.8	10.8	11.6	217.6	52.1	0.9	1626.5
2007	0.0	0.0	0.0	0.0	0.0	1245.3	0.1	0.0	0.4	5.6	201.3	42.7	0.6	1496.0
2008	0.0	0.0	0.0	0.0	0.0	1394.9	0.0	0.0	0.0	3.9	183.8	41.4	2.3	1626.4
2009	0.1	0.0	0.0	0.0	0.0	1700.6	0.0	0.0	0.0	6.4	155.0	30.2	0.5	1892.8
2010	0.0	0.0	0.0	0.0	0.0	1722.2	0.3	0.0	0.0	3.5	128.0	42.5	0.2	1896.8
2011	0.0	0.0	0.5	0.0	0.0	1623.2	48.2	0.0	0.0	6.9	178.8	31.6	1.5	1890.6

Units = Acres a = not mapped Total coverage includes all mapped eelgrass of all densities

* The acreages for 1981,1996-2008 include beds from both the NH and ME sides of the Piscataqua River but not the tidal creeks along the Maine shore.

Kalle:

This table is from the 2013 Data Report, showing eelgrass acreages until 2011. I wanted to use this as the starting point for our discussion of why we use 1996 so often as a reference point. I know one of the reasons was that 1996 was the first year that we had georectified imagery for the entire Great Bay Estuary.

Fred: Looking back through the 1990’s, there were several years where the Great Bay proper had more than 2400 acres of eelgrass. So, we decided in the early 2000’s that we could use the 1996 numbers as a recent maximum.

Kalle: In PREP’s CCMP (Comprehensive Conservation Management Plan), our goal for eelgrass restoration is 2900 acres for the entire system. That goal is up for debate as the plan gets re-addressed periodically. You could look at the historical data (40s and 60s) when we had over 3000 acres in the Great Bay Estuary,and use that as the goal. On the other hand, you could argue that we’re setting ourselves up for failure because we live in a different world now and maybe that world won’t sustain 2900 acres of eelgrass. We should have that discussion, but we won't have that in the next 8 months.

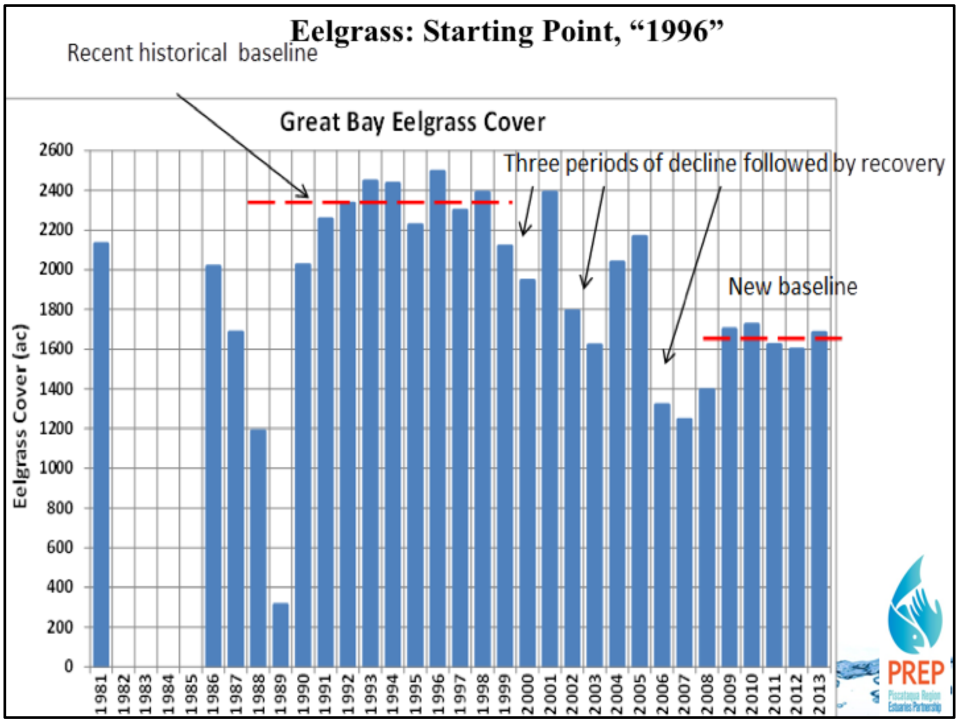
Matt Wood (DES): There are two ways that we assess. We compare the last three years (the median) to the historic reference point. Historic numbers we use are variable between different zones on the screen. We use 1948 for some areas and 1980 for others. We also have a second matrix, so if either one of these is violated (20% decrease from the reference point), it's impaired.

Committee Member: Interesting exercise to look at where in the system eelgrass could exist. Based on known depth, bathymetry, bottom, etc. That exercise may give you bounds and see how that compares to 1996 and other historical numbers.

Fred: We did implement a site selection tool with money from CICEET in the early 2000s.

Ted Diers (DES): One other thing I wanted to mention about 1996…it was also chosen because it was outside of a wasting disease event. Some of the previous high points happened directly after a wasting disease event.

Kalle: That's a good segue for the next slide.



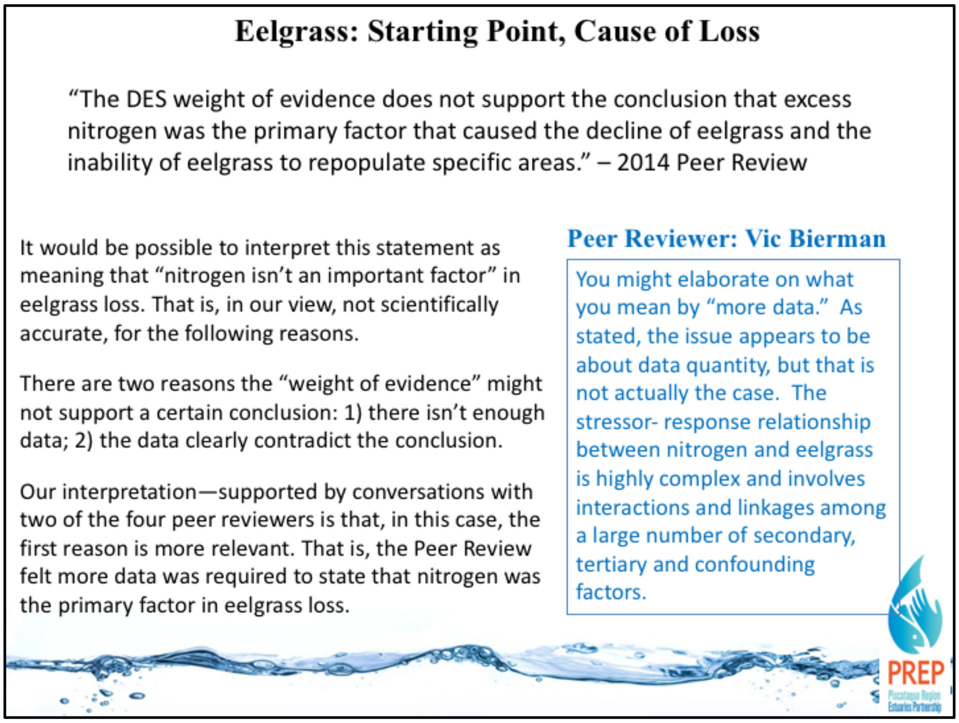
Kalle: This graph was created by Jud Kenworthy in some of the discussions that came after the Peer Review was released. Jud noted then that the only way you could possibly explain such a large change in area was by sexual reproduction and seed recruitment."

Jud: It's important to note that after the recent historical baseline, there are successive steps down, and then there is pretty good recovery, but each time it doesn't get back to the recent historical baseline. We seem to be getting to a newer baseline. The other thing to realize is that to recover from these losses, you can't just rely on asexual reproduction; there has to be seed production. The reproductive potential is present, but there is some impairment that is dampening the recovery. These plants don't produce seed banks. When they produce seeds they have to germinate in the next growing season. The seeds don't lay dormant in sediment. Most are not viable in the sediment. I think that something is going on with reproduction.

Fred: Related to that…another drag on seed production comes from goose or duck grazing.

Cory Riley (Great Bay NERR): We can help with waterfowl counts if that would be helpful.

Fred: Another idea is to do a graph like this for biomass as well.

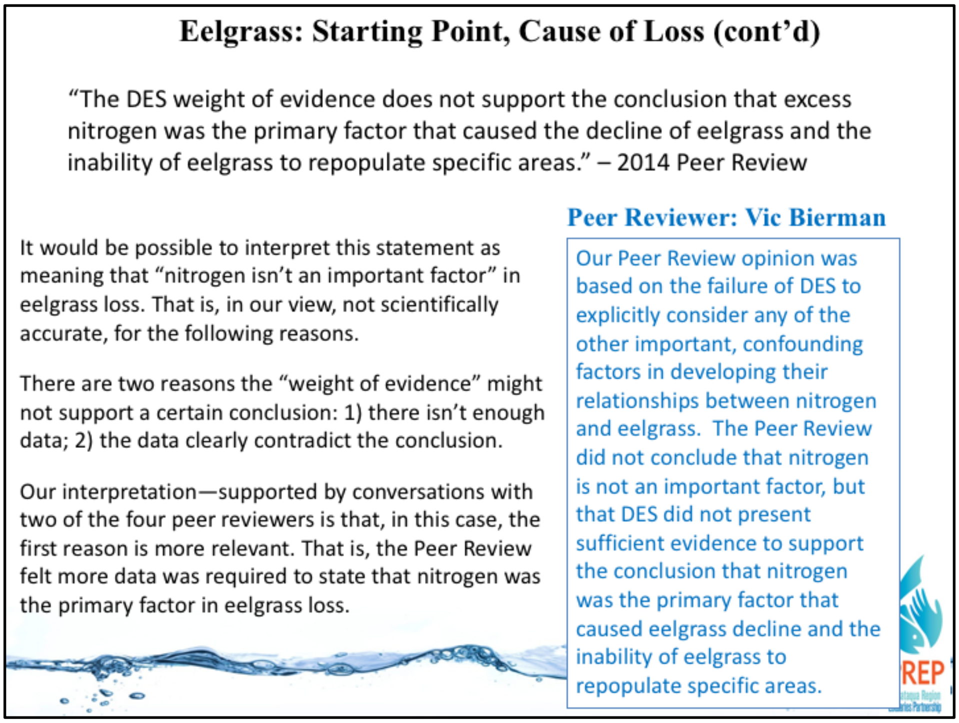


Kalle: OK, let's transition to talking about the Peer Review. This is an important document that has a lot of helpful guidance in it in terms of modifying our monitoring program to understand the changes that are occurring in our system. As a community, we're already making lots of changes and interventions; municipalities are upgrading their wastewater treatment plants and changing how they're handling stormwater. We need to study the ecosystem to see how it responds and the Peer Review offers good advice on how to look at all the confounding factors.

On the other hand, I have heard different people citing the Peer Review in different ways and I'm hearing a difference in interpretation. So, I thought it would be helpful for PREP staff to be clear, at this point in time, on a couple of points related to the Peer Review. I don't expect us to change your own interpretation of the Peer Review, but I think it's important that our view is explicit and clear to the public. I believe it is PREP's role to be a place where people can go for an official reckoning of the science. In many cases, our take won't be as aggressive as others, but that's appropriate for our role in the community…not to get ahead of the science.

So, on this slide, the sentence at the top from the Peer Review was written by

Jud Kenworthy, who was the seagrass expert on the panel. The text to the left was written by me as part of the Eelgrass/Macroalgae Primer. I shared the Primer with Vic Bierman, the lead Peer Reviewer, and you can see what his comment was. It continues on the next slide...



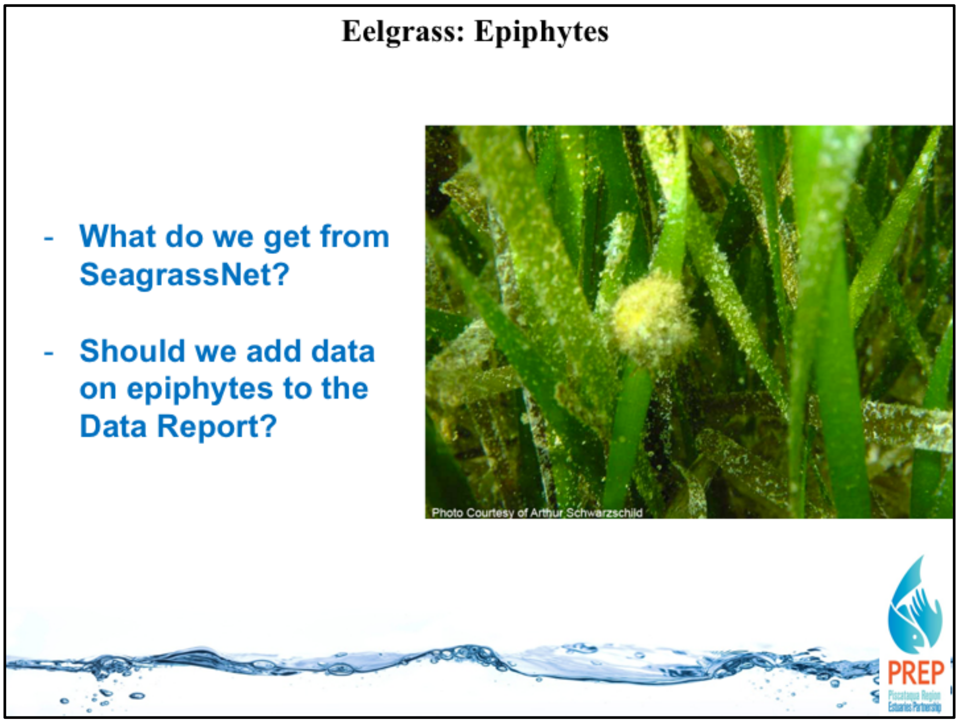
Kalle: For us at PREP, the takeaway here is that we need to do a better job at understanding the confounding. Neither we nor the peer review are saying nitrogen isn't important. Rather, the point of the Peer Review is that we can't say nitrogen is the primary factor. However, we can't just focus on the primary factor. We need to work on partitioning the various factors: how much light attenuation is from CDOM, from Total Suspended Solids (TSS), and then thinking about management actions for the different factors.

Committee Member: Curious as to why the focus is on nitrogen being the primary factor. The regulatory context is whether a stressor has a reasonable potential to cause or contribute to an environmental problem. Primary is not really the issue. The reason being that we don't often have a perfect data set but we need to make decisions.

Jud: I agree. The way the question was asked to the Peer Review panel was the wrong question. The question could have and should have asked us to deal with the confounding factors instead of just focusing on whether nitrogen was the primary factor. It was the wrong question but that's the question we were given so we dealt with it.

How many of you have read the peer review? After this meeting you may want to read it again. We raised some defensible arguments for consideration for other factors besides nitrogen. Someone else earlier mentioned focusing more on light attenuation. Based on the data the Peer Review was given, 32% of the light attenuation was due to water itself, 29% was due to turbidity, 27% was due to CDOM and 12% was due to chlorophyll-A. Now, on the other hand, we are about to focus more on macroalgae, which was suggested in the Peer Review.

I tried to bring macroalgae into the Peer Review but it wasn't one of the questions asked of us. And there wasn't very much macroalgae data for us to work with.



Kalle: The topic of “epiphytes” comes up a lot in conversation. Some say epiphytes are a clear indicator of nitrogen, but that’s not always the case. So let’s talk a bit about what epiphytes are, what they indicate, etc. Fred?

Fred: ”Epiphytes” literally means: plants growing on plants. But, in actuality, the term is usually used for anything growing on plants (plants, animals, bacteria). Eelgrass is growing and taking N out of the sediment from roots. Meabnwhile, grazers, such as snails, go up and down the leaves mowing the epiphytes. So, a lot of epiphytes can occur there because there aren’t enough grazers or there’s a lot of nitrogen, or some combination of those two things.

Kalle: Fred, with regard to your SeagrassNet work, what do you do when it comes to ephiphytes?

Fred: We take photographs. We document what we’re seeing.

Jud: The TAC should be aware that one significant thing epiphytes do is attenuate light. Like an umbrella over the leaves. They reduce light levels.

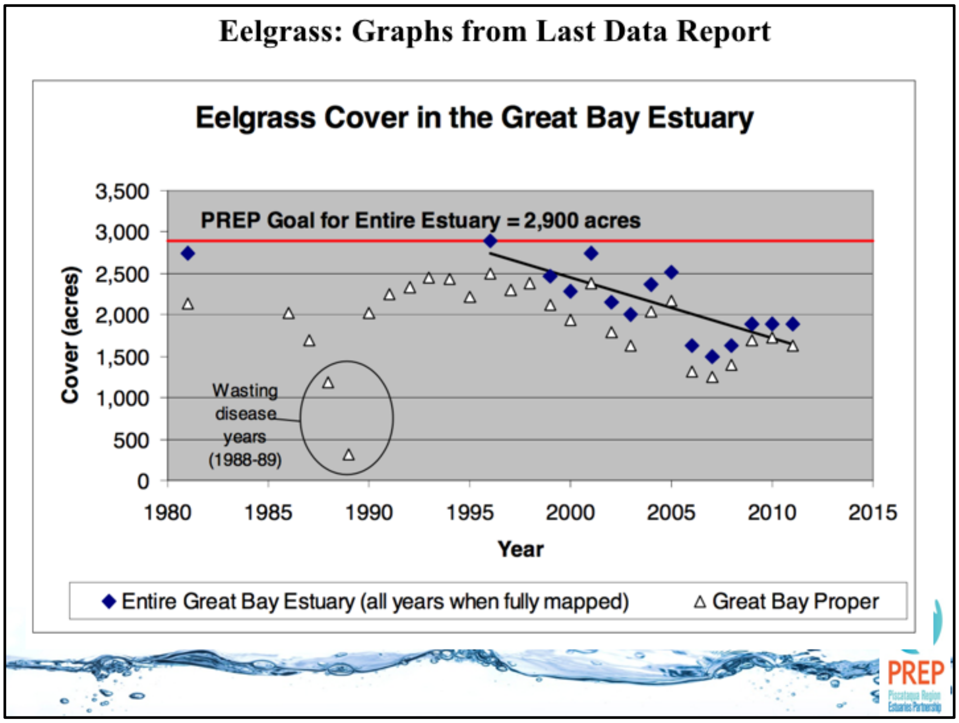
Kalle: At this point, we don’t have any firm plans with regard to epiphyte data. PREP and DES have asked Fred to go through SeagrassNet—three 50m transects in the Great Bay Proper where Fred looks at biomass, % cover, density—from 2007 up to 2016 and start to characterize what he’s seeing in those photographs.

Matt (DES): Fred you say you quantify with pictures. When you collect the eelgrass to weigh, are the epiphytes removed?

Fred: Yes, but not measured.

Jud: For those of you who don't understand how eelgrass grows, it grows like a conveyor belt. The meristem is at the base of the shoot, and as it divides the leaves grow up into the water column. The younger leaves speed up and the older leaves slow down. The epiphytes attach themselves to the outer, older leaves and then, 40-50 days later, the old leaves slough off. This is important because when anything impacts growth rate, that provides more opportunities for epiphytes to attach, because you're slowing the conveyor belt down. This can create a spiraling feedback system. It's one of the ways epiphytes accumulate and have an impact.

David Burdick.: Just want to point out that wasting disease is similar. Typically, wasting disease is much slower than eelgrass growth under typical conditions, but when growth slows down, wasting disease has more of an impact.



Kalle: Now, we'd like go through the visuals that Phil used in the last Data Report. We'll go through them once and then go back and talk about ways to better display the data.

Committee Member: For this graph, and the next one, I'm struggling with the lack of uncertainty measurements.

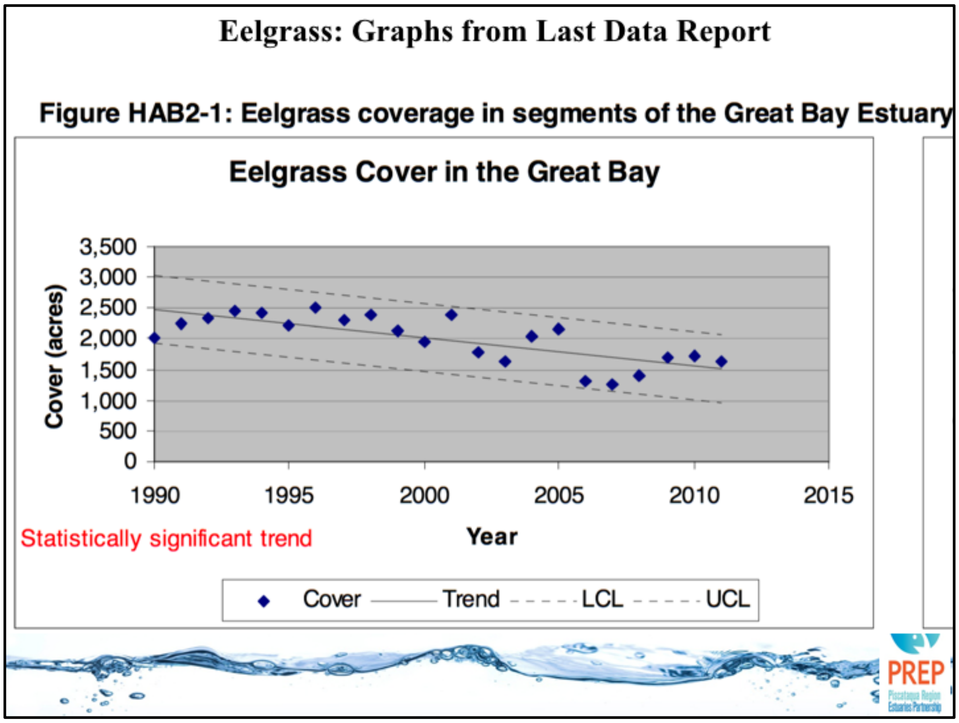
Jud: That's always an issue with mapping data. An alternative is to do accuracy assessments and develop an accuracy matrix. That will be useful in terms of looking at a macroalgae problem and discriminating macroalgae from eelgrass.

Matt (DES): Don't forget that, in 2013, we had two people (Fred Short and Seth Barker) do mapping. Need to think about how that gets portrayed. Also looking at the maps (presence/absence and density classes), what came out of that it's really the individual making those assessments that influences. We need to think about how to address that issue of how different people will characterize percent cover differently.

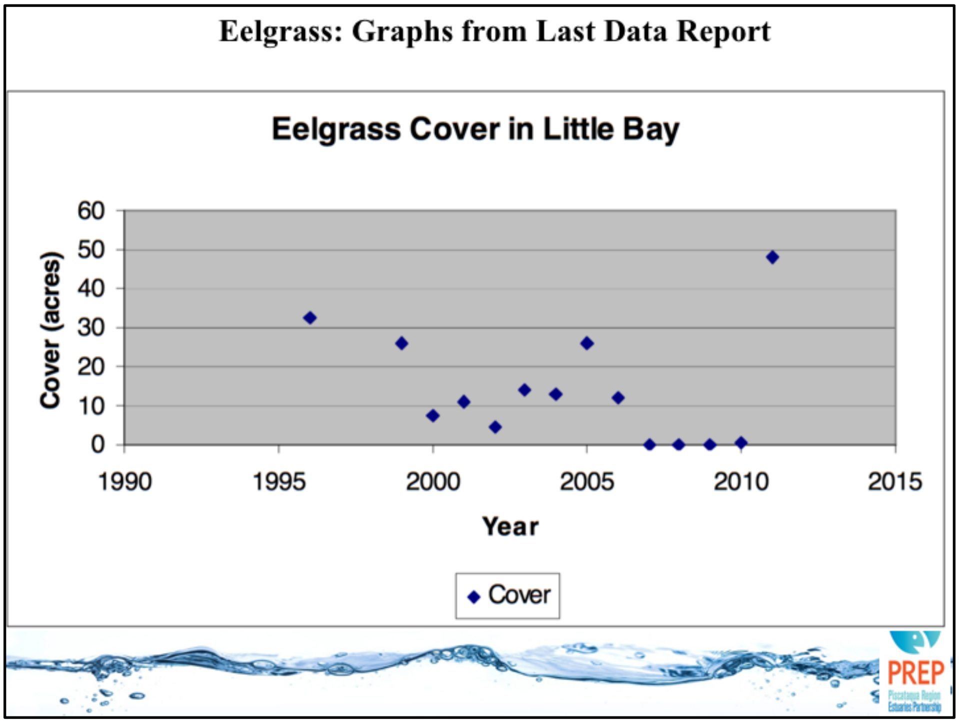
Committee Member: A comment to consider for the overall report. It seems here that the regression line starts at 1996. Prior data is included, but not in the regression. Just try to be consistent throughout. This was brought up 4 years ago. Jud: I just want to clarify my comment about an "accuracy assessment." In mapping, a photointerpreter will develop a series of polygons that classify something on the bottom. A true accuracy assessment would take that polygon and generate some random points, and verify in the field whether the interpreter accurately assessed those points or not. You can develop statistics for that and it allows one to deal with the misinterpretation of different signatures and interpretations:

Matt: Agreed, and that's basically what we did for the two different data sets in 2013.

Committee Member: For public consumption, some of these graphs offer more information than folks really need. You might want to give some thought to that…breaking it down more simply. For example, the bulleted descriptions of loss described in the 2014 Eelgrass Report are very clear and to the point.



Kalle: No comment here.

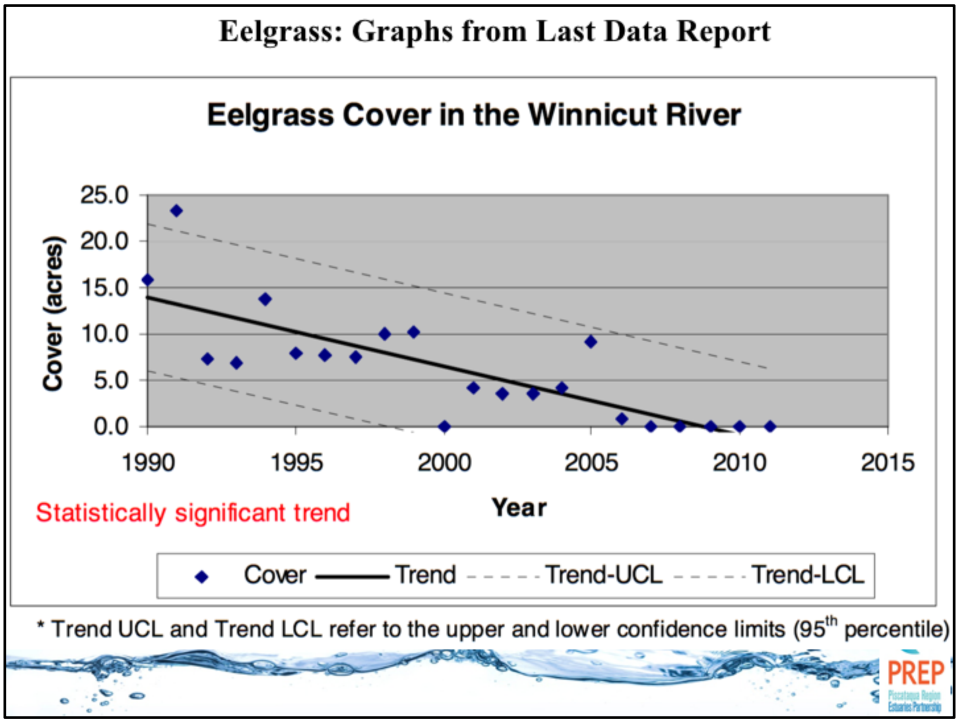


Kalle: Fred, did you have a comment here?

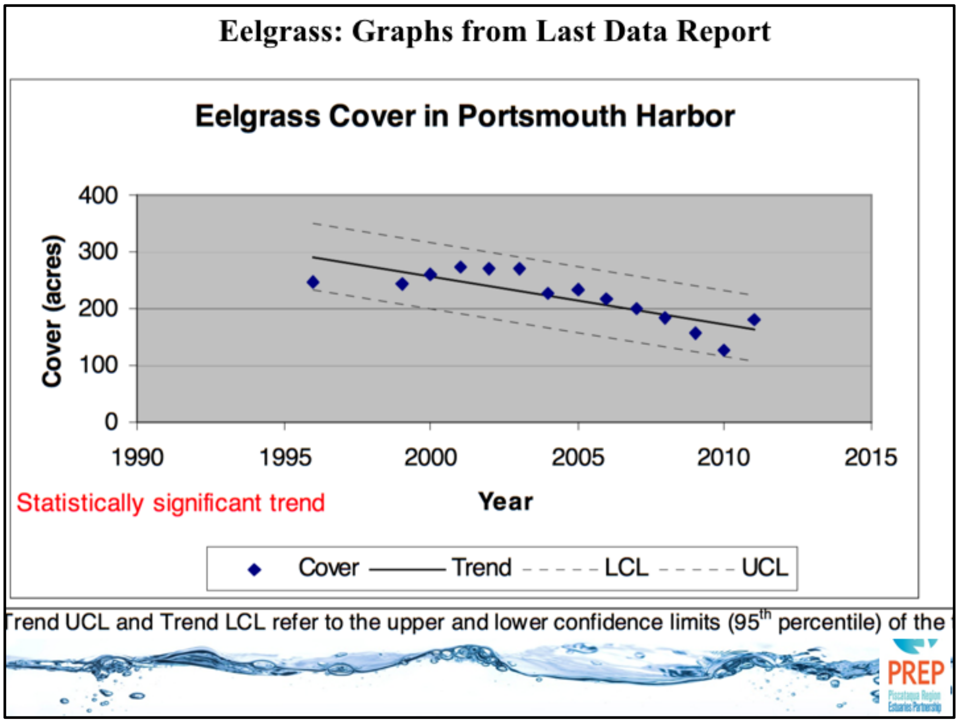
Fred: Just that you don't see a trend because there are several beds that come and go depending on seed production. They come in, grow for few years and then disappear.

Ken Edwardson (EPA): I remember seeing an historical number for Little Bay. Is it possible to work that into the graphs?

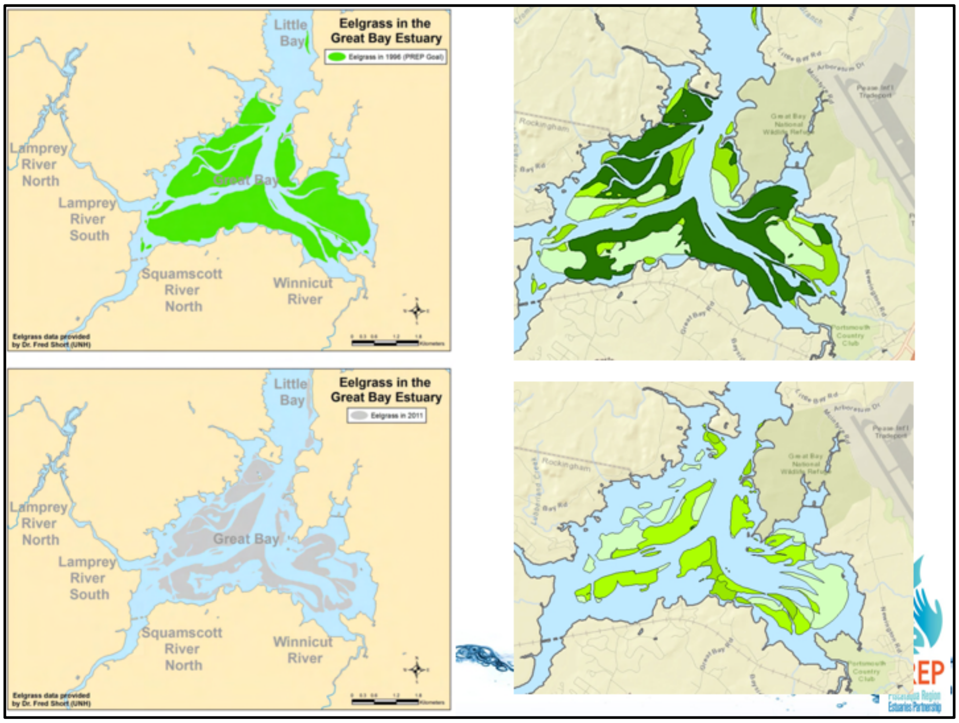
Fred: It may be possible. Those numbers came from a Fish and Game report, I believe. I believe that number showed a lot ore acreage than we're seeing now.



Kalle: No comment.



Kalle: No comment.



Kalle: On the left, you see maps of the kind that were used in the last Data Report. Notice that there's only color in those maps; they indicate presence/absence of eelgrass. On the right, you see maps that have different shades of green, with the darker shades denoting denser eelgrass. Right now, I'm leaning towards using these latter kinds of maps as they offer more information.

Well, that's an overview of the kinds of data we're looking at providing for eelgrass. Are there any general questions or comments?

Committee Member: Curious to the absence of any data on light attenuation or transparency, and the causes for some of those conditions.

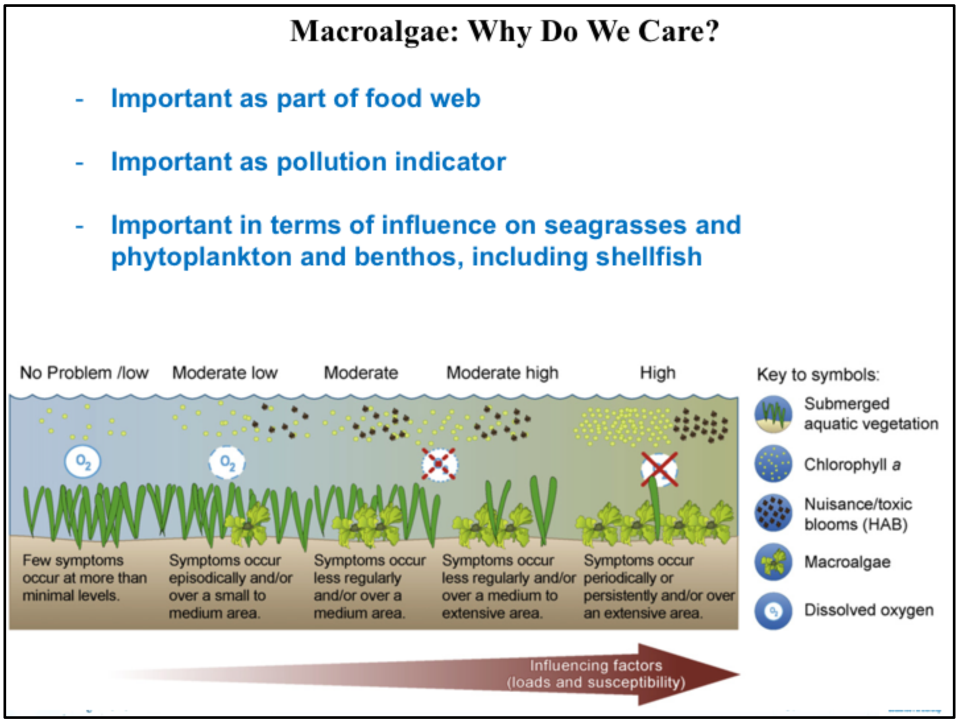
Kalle: We are looking at whether we can include light attenuation data from the GBNERR and PREP sampling and from the NERACOOS buoy; these datasets go back approximately 10 years. Not sure yet, but we'll know more around February or March.

On that same note, at the last meeting, we talked about trying to include air and water temperature, river discharge, and CDOM in addition to light attenuation.

Committee Member: Is detailed bathymetry available for Great Bay?
Semme Dijkstra: Yes

Committee Member: It might be interesting to use that as a backdrop with these maps. Find out how changes are occurring with regard to depth.

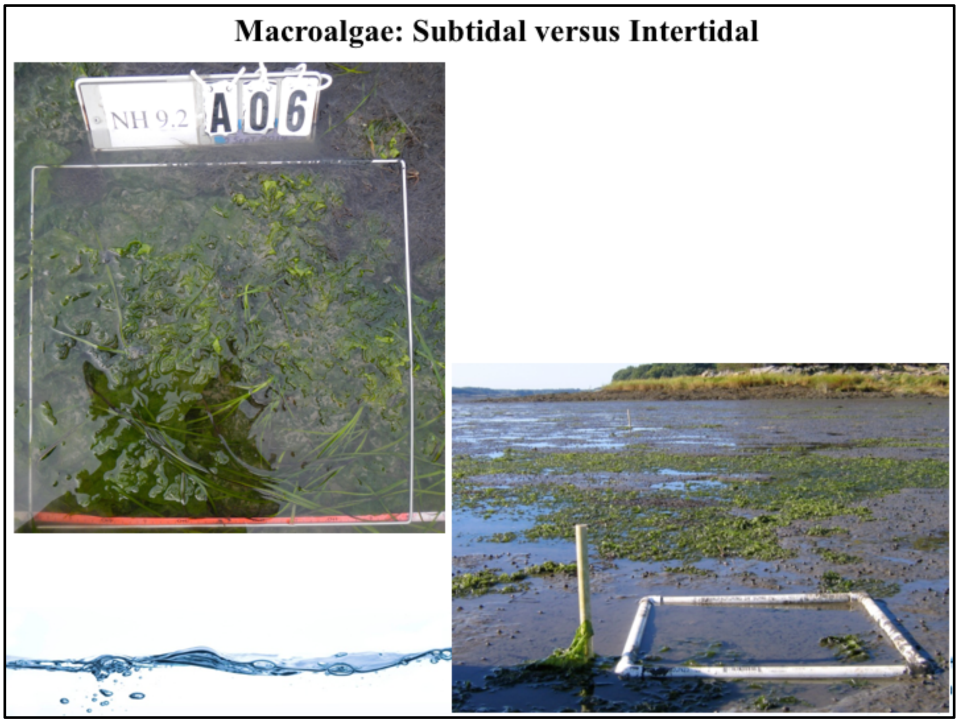
Semme: I can talk to Larry Mayer (UNH Center for Coastal and Ocean Mapping and the UNH School of Marine Science and Ocean Engineering) about getting that data.



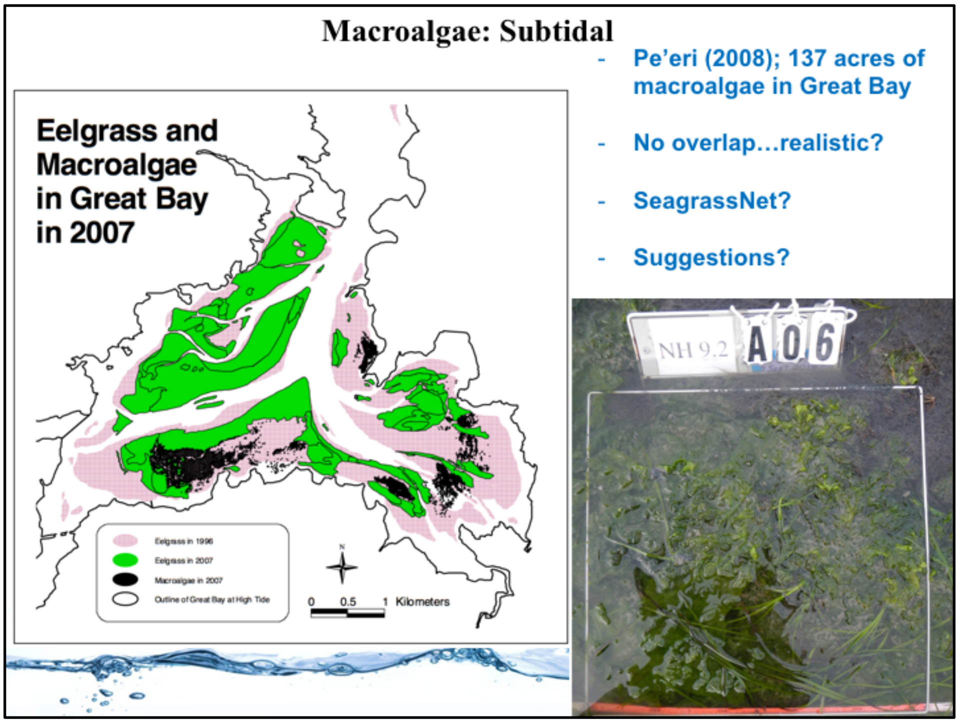
Kalle: Why do we care about macroalgae, also known as seaweed? First of all, it's an important part of the food web. Even algae that's considered a nuisance can provide important habitat for critters. (By the way, I tried to discover what makes a certain seaweed a nuisance, and there's no real definition of nuisance algae other than it grows way too much and overtakes your system and causes it to degrade. It's important to recognize that there are many kinds of seaweed. Seaweeds are also used as a pollution indicator. Finally, seaweeds are important in terms of influence on seagrasses and phytoplankton and benthos, including shellfish.

In this slide, there's a graphic that's taken from a paper by Suzanne Bricker; this particular graphic has to do with eutrophication, but that's not my focus right now. I just want to show that there's this classic progression of a stressed system that goes from left to right, from lots of eelgrass and little algae (both macro and micro) and then reverses to very little eelgrass and lots of algae. However, sometimes the microalgae (plankton) can be moderate/moderate low (particularly in systems that are well-flushed) but the macroalgae can accumulate and replace eelgrass.

Jud: That's true, but you can get piles of macroalgae in unvegetated areas. Those black dots—which indicate HABS—could just as well indicate suspended solids because that happens often in a degrading system. That's something we need to look into for this system. How much are suspended solids attenuating light and how much of that is little pieces of macroalgae?



Kalle: We have to think about seawood both interidally and subtidally. Most of the data we have is intertidal, that is areas that are submerged part of the time and exposed part of the time. However, a big part of the problem is what is happening subtidally. On the left, we have Fred's photo from his 2014 report. You can see that there's eelgrass in that quadrat, but there's also a lot of ulva. The other photo is from a report lead by Jeremy Nettleton and shows mostly Ulva in the intertidal.



Kalle: Let's talk about seaweed in the subtidal. This map you see on the left was in the 2013 data report; it tries to get at what's going on in subtidal for one specific year. The lead author was Pe'eri and the report documented 137 acres of macroalgae in the Great Bay Proper.

The other thing to point out here is that this map doesn't show a whole lot of area where eelgrass and seaweed comingle; in other words, it's either eelgrass or seaweed. Not sure how accurate that is. Personally, I've been spending time in the bay the last 2 years, and most places you go there is macroalgae in the eelgrass beds; they're entangled together.

Fred: That was almost 10 years ago, and I think we have more macroalgae drifting around now. The beds on the western side of bay there was long eelgrass and dominated the imagery. You couldn't see through the eelgrass. Only looks at top.

David Burdick.: This method—using hyperspectral imagery—also didn't distinguish between different types of macroalgae. Picked up the reds pretty well, but had a harder time distinguishing green algae from eelgrass.

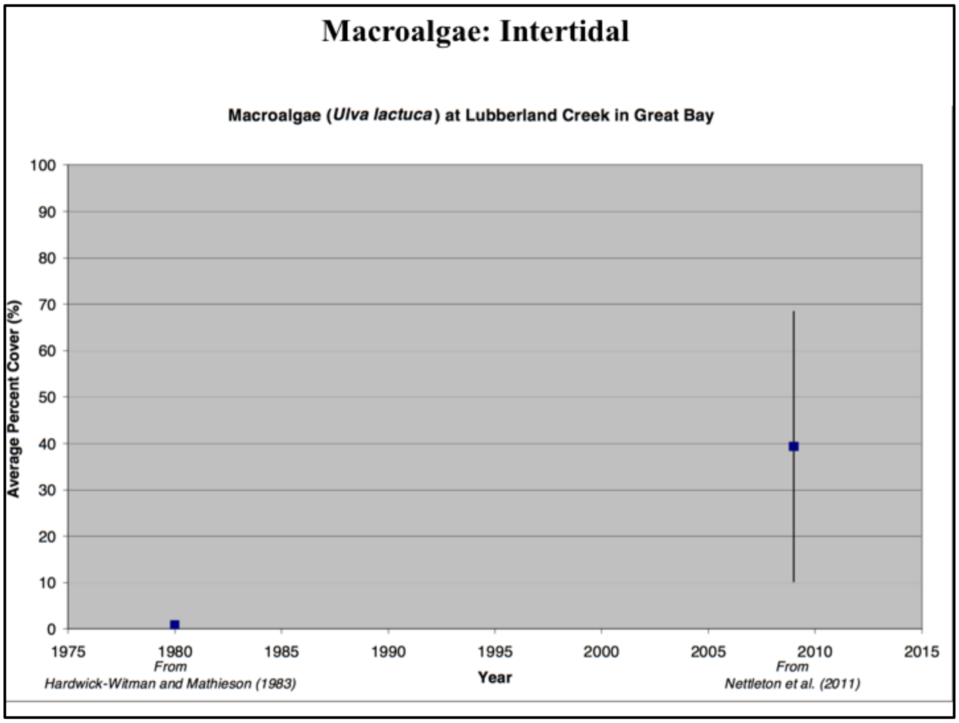
Kalle: With SeagrassNet, we are hoping to add to our repository of data on this subject, going back to 2007. Also, I recently learned that we also have some SeagrassNet data from Portsmouth Harbor? Fred?

Fred: Yes, going back to 2001. Still doing it but there hasn't been any eelgrass at the particular transect location.

Kalle: Any suggestions at this point?

Ted Diers (DES): Future suggestion. Relative to David Burdick's work and SeagrassNet. A weakness is not having transects that go through all of the habitats. I know that requires a lot of work, but that is really the limiting factor. We don't get to see that whole transition as it occurs and we need it.

Art Mathieson: In my view, it would be great to have transects from the tree line to the edge of the photic zone (the area of the water column that receives sunlight). But it's difficult. These areas are like quicksand, not very inviting and actually a bit dangerous. If you aspire to do this, money is one thing, but time is also necessary and there are a lot of logistical considerations. The reason we've focused mostly on shallow intertidal is a result of accessibility.



Kalle: So, this graph is from the last Data Report and it's a bit underwhelming. But since this time, we've gotten more data and have a bit more of the story. We'll go into that more on the next slide.

Tracking environmental trends in the Great Bay Estuarine System through comparisons of historical and present-day green and red algal community structure and nutrient content

Jeremy C Nettleton, Christopher D Neefus, Arthur C Mathieson, and Larry G Harris
University of New Hampshire, Department of Biological Sciences, G28 Spaulding Life Science Center, 38 Academic Way Durham, NH 03824, USA

Final Report Submission Date: March 2011

Host Reserve: Great Bay National Estuarine Research Reserve System

Kalle: I'd like to spend a little time going over the goals and results of the Nettleton report, which came out in 2011. Just as a reminder, you can access all the materials we're talking about today on the TAC web page at: http://prepestuaries.org/prep-technical-advisory-committee/

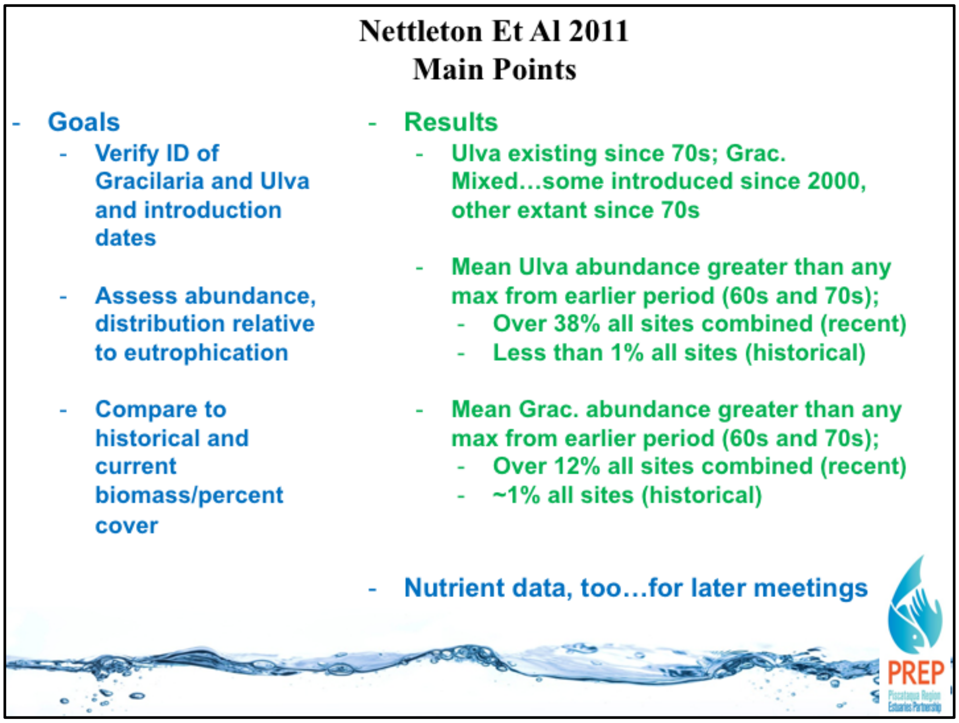
This work was sponsored by the Graduate Research Fellowship program, associated with the National Estuarine Research Reserve System.

Nettleton Et Al 2011
Main Points

- **Goals**
  - **Verify identity of bloom-forming Gracilaria and Ulva species in Great Bay**
  - **Determine introduction dates**
  - **Assess abundance, distribution of Ulva and Grac. relative to eutrophication patterns**
  - **Compare to historical and current biomass/percent cover to sites where previously conducted**
  - **Compare historical and current water quality measurements throughout GBE re: nutrient availability**

PREP

Kalle: On this slide, you can see the goals of the report…



Kalle: And here you can see some of the results. The study found that the Ulva species has been around since the 60s or so. In terms of the Gracilaria, some species were introduced after 2000; other species had been around since the 60s.

Jud: Has anyone accurately identified where the invasive species came from? That is, how they were introduced?

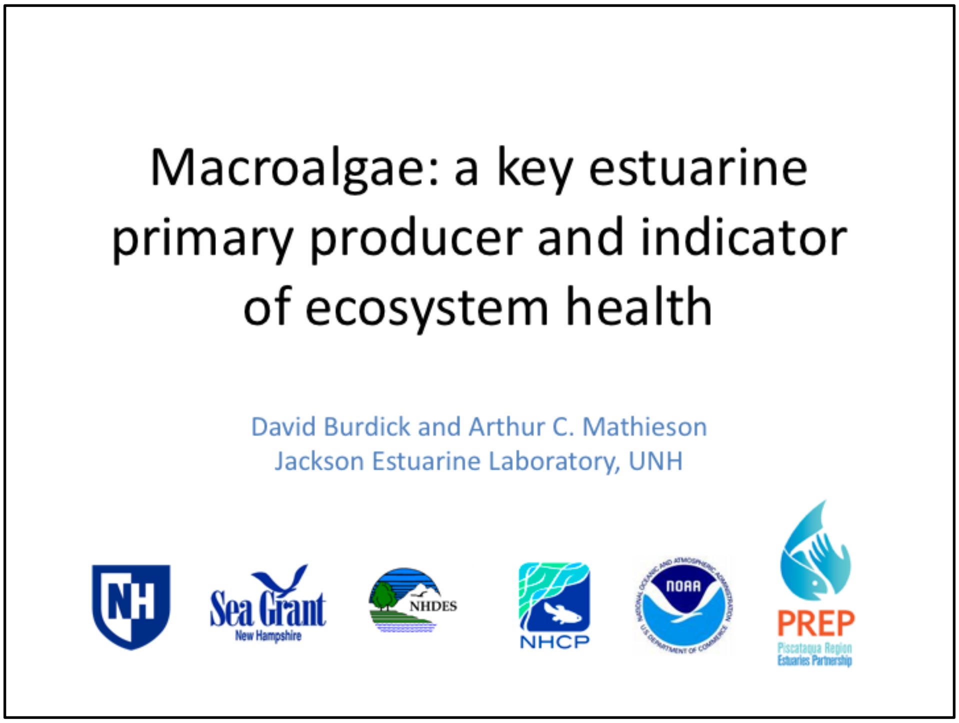
Art Mathieson: We don't know for sure. Could be coming off of boats; could be shellfish aquaculture. It's largely speculation. Problem with this data is that we now know you need molecular tools to determine particular species in some cases.

Kalle: The other big results were that the mean abundance levels of the ulva from the various sites in the study was greater than any maximum from the earlier period. In terms of percent cover, they found an average of over 38% combining all sites, compared with only 1% during the 60s/70s.

With regard to the Gracilaria, it was much more abundant compared with the

60s/70s and percent cover average was over 12% combining all sites, compared with approximately 1% in the earlier studies.

Both this report and the Ciancola thesis (http://scholars.unh.edu/prep/41/) also have lots of data on water quality as it relates to macroalgae, but that's outside the scope of what we're covering today.



Kalle: Handing it off to David Burdick…

Dave: Throughout the 90s, most of us didn't really think about macroalgae. In 2000, people were making noises that we should be considering macroalgae. We need more information on light attenuation but one study indicated that chlorophyll-a from phytoplankton only accounts for 12% of the light attenuation. But that study doesn't take into account shading by macroalgae.

Primary Producers in the Estuary:

Microalgae:

- Phytoplankton (drift in the water)
- Benthic diatoms (grow on the bottom)
- Epiphytes (grow on other plants)

Macroalgae:

- Brown, Green and Red seaweeds (subtidal and intertidal)

Seagrass:

- Eelgrass and Widgeon grass (subtidal)

Marsh Grass:

- *Spartina* grasses (upper intertidal)

Dave: Just want to mention the primary producers we have in the system. ["Primary producers" are the organisms that produce biomass from inorganic compounds.], We have phytoplankton; we have benthic diatoms, epiphytes growing on other plants and macroalgae. I mention marsh grass as well as they are extremely productive, but they probably don't have as large a role in the eelgrass, macroalgae and benthic community system.

Dave: Just some photos so that you can see examples of red, green and brown algae. We've talked a lot about Gracilaria, in the upper left, which is a red algae. Another one seeing out there is Dasyphonia japonica, in the lower right, a new invader from Asia. It doesn't produce as much biomass as Gracilaria but can grow a lot amongst the eelgrass.

From upper left to bottom center:
Chaetomorpha linum
Ulva (blade)
Ulva (tube)
Cladophora albida
Cladophora sericea
Photos from Raposa et al. (2011); *Ulva* (tube) from uniprot.org.

Green algae tightly bound to mud - looking like moss is often *Vaucheria* sp. (marsh felt)

Dave: Here are pictures of the greens. Across the top are different versions of Ulva. On the bottom, you see Cladophora, which can really proliferate and become a real nuisance, but we’re not seeing it to that extent here.

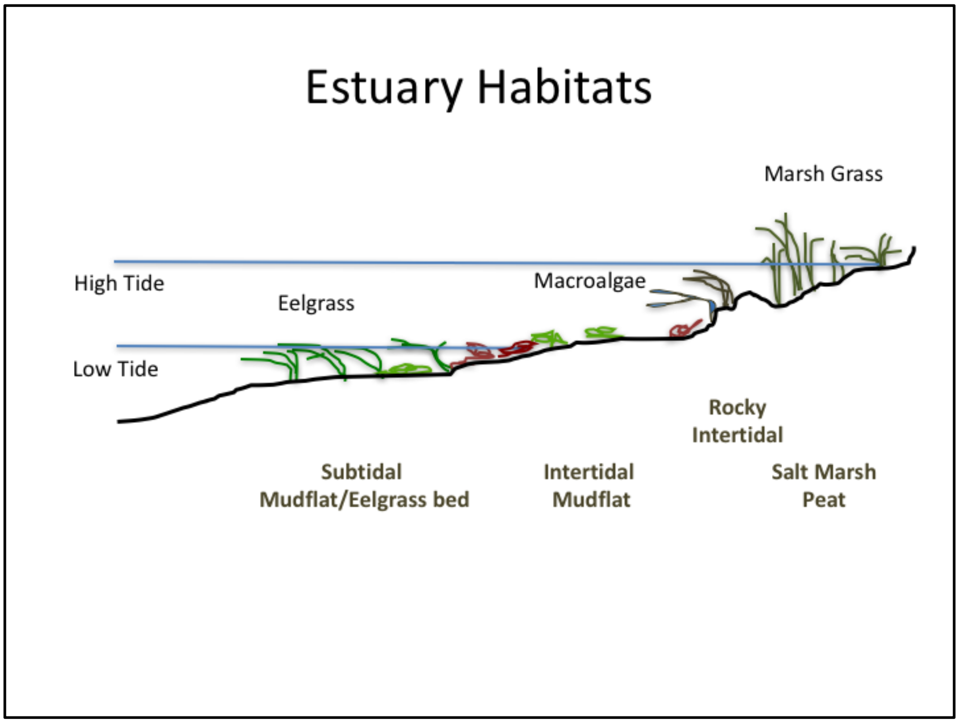
From upper left to bottom center:
Ascophyllum nodosum
Pylaiella littoralis (magnified)
Fucus spiralis
Fucus vesiculosus
Photos from Raposa et al. (2011) and AlgaeBase.

Dave: Finally, we have the Brown algae, which put a lot of biomass in the estuary. They provide a lot of primary production and usually grow on rocks, not overlapping with eelgrass. Sometimes, they protect oysters that are growing intertidal.

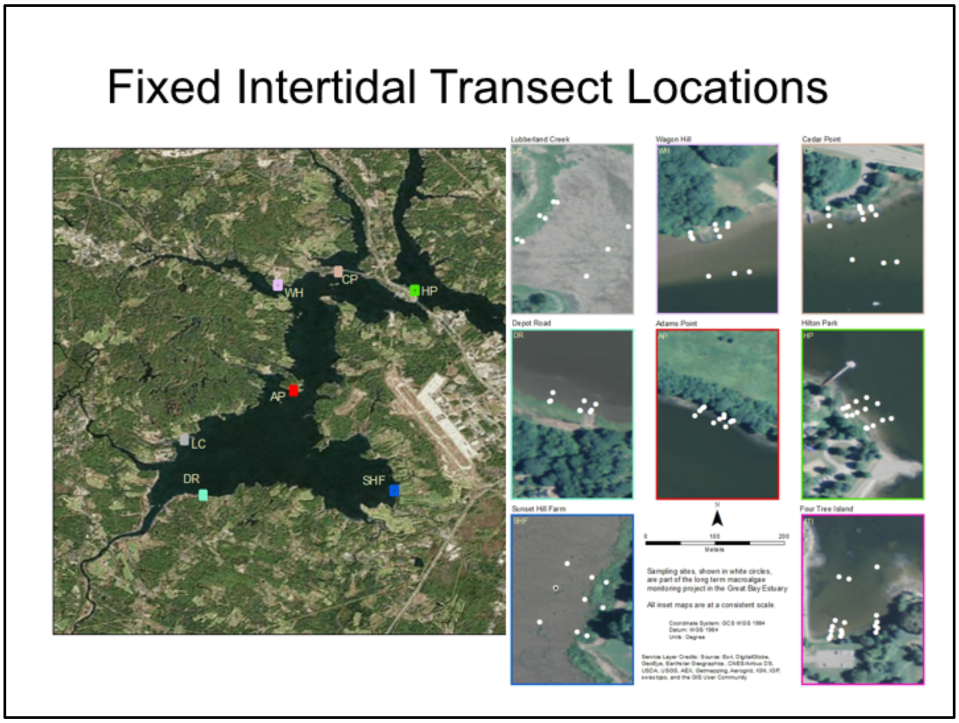
Kalle: Jud, you mentioned something to me yesterday about the light needs of macroalgae compared to that of eelgrass. Can you say that again?

Jud: Seaweeds have an order of magnitude lower light requirement than eelgrass. They have a unique advantage if light is diminished. Some seweeds only need a fraction of 1% of “surface irradiance (light)”, whereas eelgrass can require between 15 and 25% surface irradiance. The light requirements of eelgrass tend to increase when there’s more organic content in the sediments and when waters are more turbid.

Dave: And algae can absorb nitrogen through every cell, so they take up nutrients much faster than seagrasses.



Dave: It's important we think about these as a whole system. 20 or 30 years ago, mud flats were largely bare and now we are getting more macroalgae. If oysters were part of this diagram, they'd be mostly in the subtidal, though some can be intertidal. Soft shell and razor clamsare in the mud flats as well.



Dave: Before 2013, we worked with Phil Trowbridge to better understand how much macroalgae is in our system. We could look at intertidal, or subtidal, or we could look at both. We decided to focus on the intertidal. Here's a map showing the sites. The Hilton Park site was added to capture the flow of the upper Piscataqua and Cocheco.

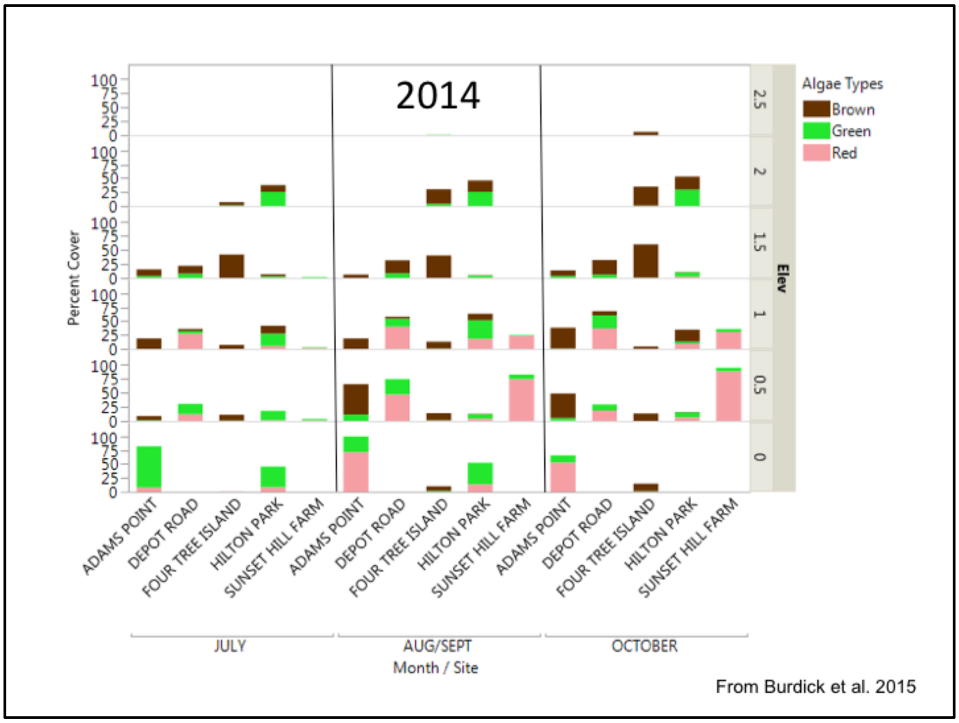
We established fixed transects that go from the upper edge to 0 elevation relative to low tide.

META-RESULTS

Abundance of macroalgae varies by:

- Site
- Elevation
- Season
- Year

Dave: Abundance of macroalgae varies by site elevation, season, and year.



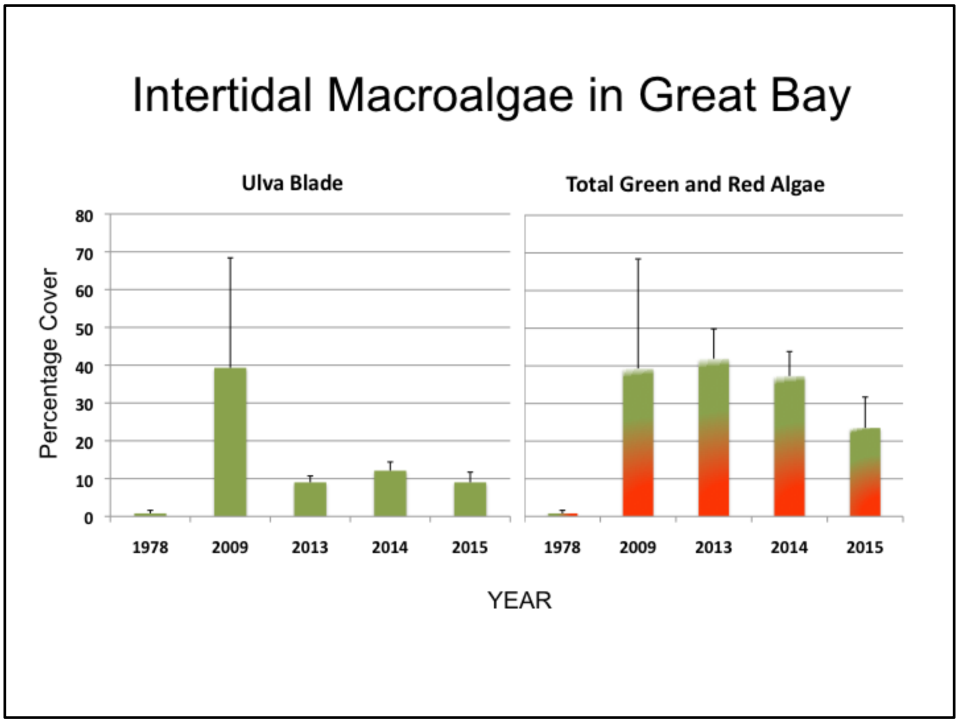
Dave: This graph shows data from 2014 only. Just want to give you a sense of the data. The observations come from July, August/September, and October. As you can see from the two vertical axes, we have percent cover and, also, going from low to highest elevation. The legend shows you the color coding for the different kinds of algae: browns, greens and red. You see that the Browns grows on rocks and usually at higher elevation. There are more greens in spring and the reds come in mid-summer. As you see, it's very variable.

If I were to show you a similar graph for 2015, you'd see that the sites change. We don't go to all sites every year. We have 8 different sites, and we always go to Depot Road and Adam's point, but we alternate the others from year to year. This was done because of limited resources.

Kalle: Thoughts on this graph?

Committee Member: I wouldn't show this figure as shown. It's too much to take in. Rather, it needs be compiled and condensed in a more focused way.

Kalle: And we'll have clearly explain the alternating of sites.



Dave: This graph is trying to show the big picture, looking at averages. You can see on the left that Ulva (Blade Only) levels were very high in 2009 and lower levels around 10% cover after that.

When you look at total green and red, you can see that red is becoming more important. It seems like around 30% cover is the new normal.

Committee Member: Do you feel that these graphs represent what you're seeing in the estuary?

Dave: As always, I would like more data…don't always feel like these intertidal data are characterizing the whole system. And of course, as we've discussed, we don't know how this reflects what's going on in the subtidal.

Committee Member: Is it possible that you could present in tandem with this the ranges in the published literature? You guys know macroalgae…many of us don't. For example, in stormwater, one can use the National Stormwater quality database and use the criteria to provide reference. These numbers are hard for me to grasp in terms of what I'm supposed to takeaway.

Kalle: It's a good idea.

Fred: I think we can also do a better job explaining what we see here, how we arrive at percent cover, what it means, etc.

Jud: One of the ways to do that would be to add a legend with a quadrat and 2% and another with 20% and 40% so people can visualize the information.

Kalle: Thoughts on this chart?

Rich Langan: This graph needs a lot of clarification. It doesn't seem to make sense that when you combine reds and greens on the right, you have the same percent cover as on the left.

Steve Jones: If part of the problem is that you have two consistent sites and some alternating, you may want to consider focusing on the two consistent sites and using the others as backup…context.

Fred: I'm concerned that doing that would leave us with too little information. I would encourage us to find the resources to do more sites regularly.

Two Associated Efforts:

1) Developing predictive associations between algal cover and biomass (e.g., Regressions) by species
2) A re-examination of quadrat photos 1978, 2008-2010 and 2013-2016

Dave: Want to switch gears here and talk about some other projects going on.

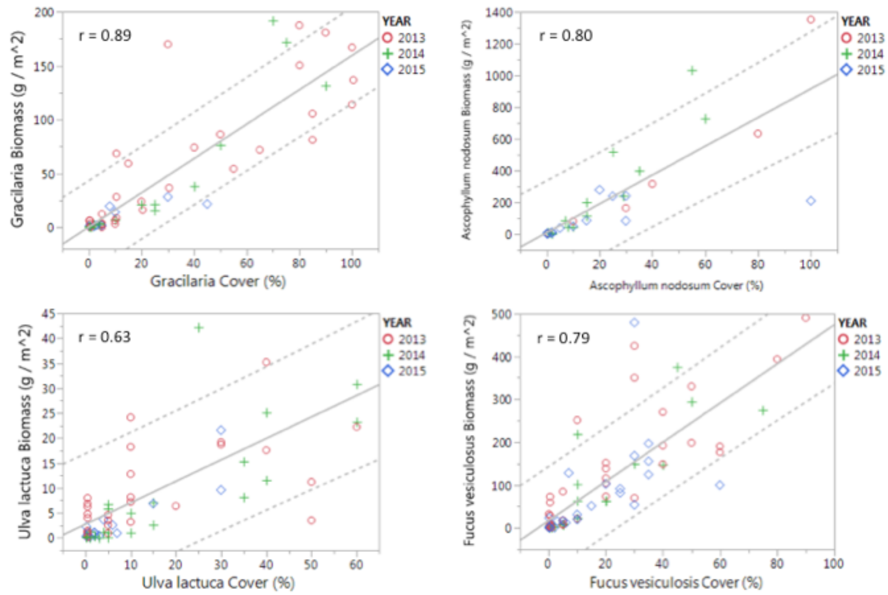
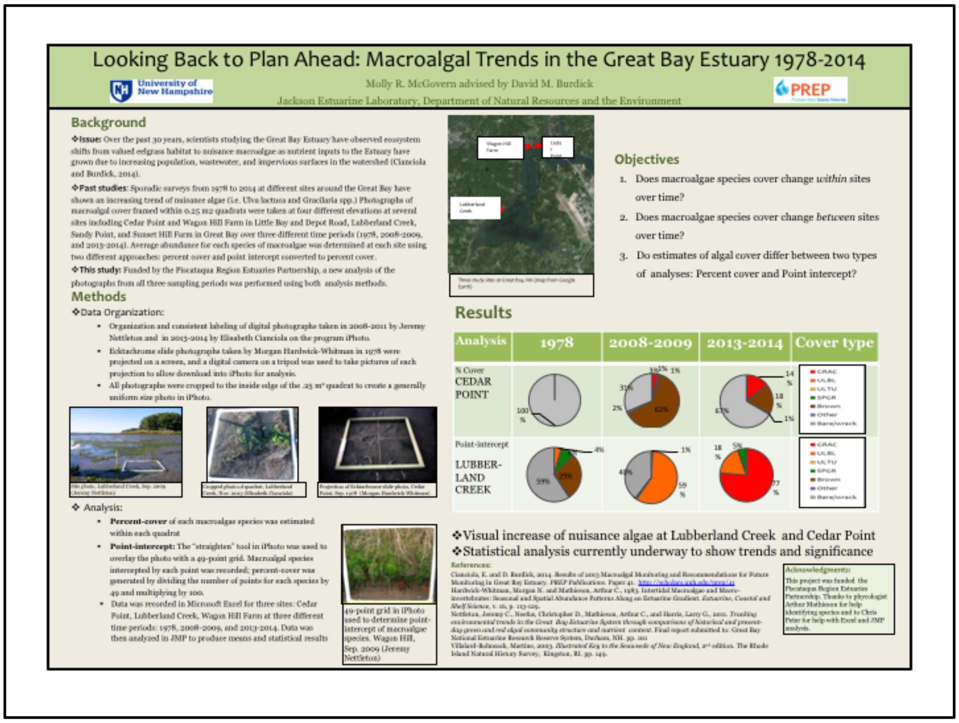
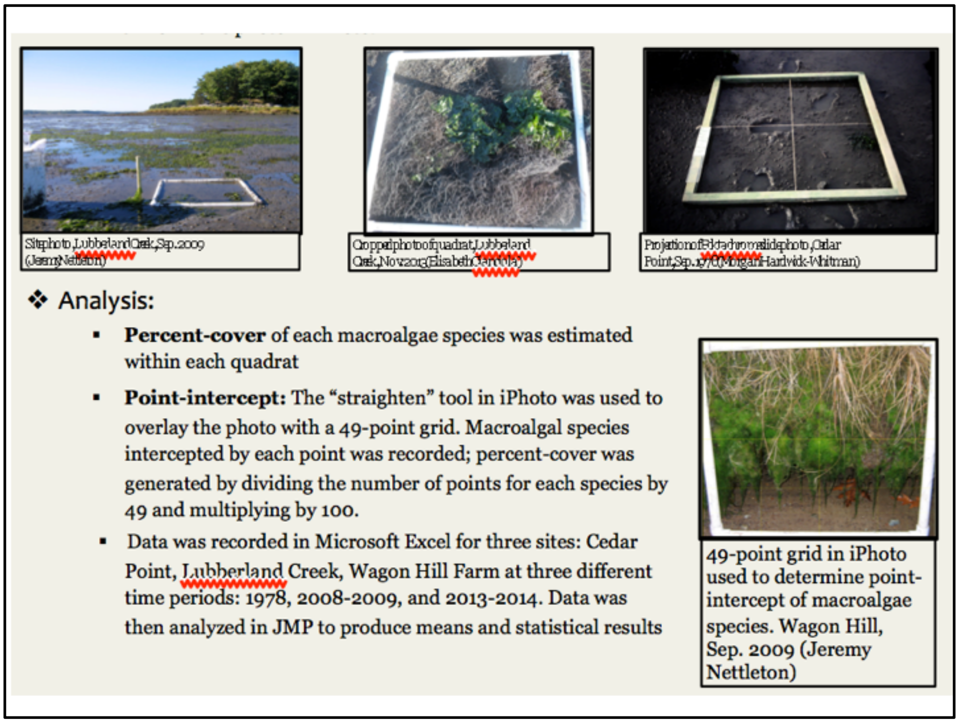


Figure 7. Correlations of percentage visual cover vs. biomass from 0.0625 m^2 quadrats for the 2013, 2014 & 2015 combined data. Best fit lines and 90% confidence intervals are shown. Outliers were excluded from Gracilaria (6 excluded), Ulva (8), Ascophyllum (5) and Fucus (5) using Quartile Robust Fit method (JMP 2015).

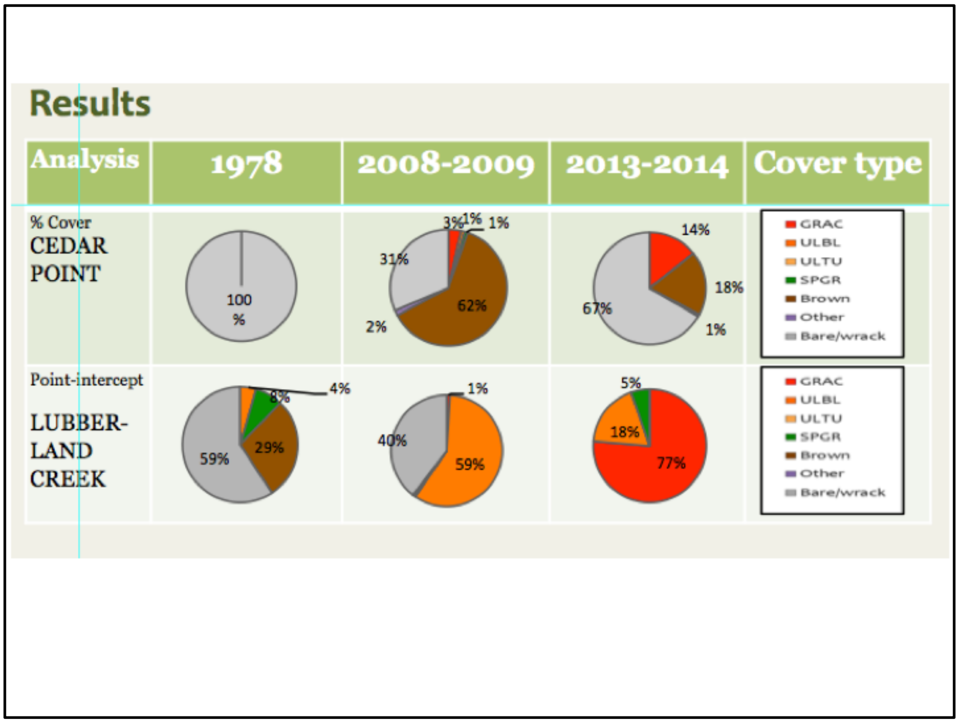
First, part of the intertidal effort includes collecting algae samples, assessing biomass and developing a regression that relates biomass to % cover. That way, if we know the % cover we can estimate the biomass.



Dave: Second, I'm working with a student, Molly McGovern, to re-examine photos from 1978, 2008 through 2010 and 2013-2016, and try and use different methods to more objectively characterize change.This a poster put together by Molly. The next slides allow us to zoom in on different parts of this poster that I want to talk more about.



Dave: As we've discussed, it can be a bit subjective sometimes to just estimate percent cover in a quadrat. Using photographs we're comparing the percent cover estimation method with a "point intercept" method, where we add a grid (7X7) and then count how many of the intersection points on the grids actually are covered with algae. We're hoping this will give us a more uniform assessment of what was in those plots.



Dave: Here (also a zoom-in from the poster) you see an analysis of data from Cedar Point and Lubberland Creek, looking at changes in percent cover and also in the point intercept estimation.

Committee Member: For the 2013-2014 segment…is that Gracilaria invasive or native?

Dave: I believe it's both.

Committee Member: It's important to know and distinguish, because one could be a nutrient problem and one could be an invasive species problem. Different ways of addressing those problems from a management perspective.

Art Mathieson: We know that some of these algae are native species that have been here for thousands of years, and some are introduced species from Japan. I agree that it's important to do as much as we can to delineate the differences. To do it with photographs…that's a difficult job, but maybe our questions can be answered with biomass sampling. To me, biomass is very important.

Paul Stacey: Agree with the above and that biomass is important.

Ken Edwardson (EPA): I would add my agreement to the others. Also, as was said earlier, let's give the information on how much algae biomass is enough to start changing the sediment in way that impacts eelgrass in a bad way. Let's goes numbers from the literature as a comparison. That's critical.

Committee Member: How do you account for where you put your quadrat if you are sampling in an area with no algae and you see an area near you that has lots of algae but isn't within your random sampling regime?

David: It's frustrating. That's why we need to talk about other ways to try and capture the big picture, perhaps similar to how we map eelgrass for the whole system.

Committee Member: Let's be careful about the terms "invasive" and "nuisance." Both natives and invasives can be a nuisance. We just need to be clear.

Fred: I agree. Both can be a nuisance and they both proliferate in response to nutrients.

Kalle: And both proliferate in response to other factors such as warmer water.

Art: Agree. Water temperature is very important.

Fred: I just meant that algae can expand from warmer water, but even with warmer water, there have to be nutrients in the water for it to expand.

Rich Langan: I does seem that we know more now than we knew in 2013. Yet I'm concerned about how we report on this for the SOOE. I don't think we have enough data even now to say somethin conclusive about the proliferation of macroalgae. One thing we can say is that we are noticing introduced species that are accounting for what we are perceiving as proliferation of algae. My take away from much of this is that it's a problem of invasive species.

Art Mathieson: I continue to hear comments related to new information or a lack of information. Let me give my perspective as someone who has studied seaweeds since the 70s. I don't consider this to be new information. Its application is new. A lot of what's going on is known in other areas. In Narragansett and Waquiot Bays, there's a clear history. The patterns that we are seeing here are a repeat of what's going on in other places. It's important to take this good information from other estuaries and think about it relative to our own situation. The fact that we are seeing more green algae here is a worldwide phenomenon. The Baltic Sea and how eutrophication has affected it is another example. We aren't as unique as we think we are. Finally, don't forget that there's a lot of untapped information around, such as from herbarium records.

Committee Member: One system to look at for comparison might be Barnegat Bay.

Dave Burdick: When we started this protocol five or six years ago, we looked back through the literature to look for protocols. There really wasn't anything published or in the grey literature. I agree with Art that there are patters we're seeing in New England and worldwide, but what we seem to be wanting is more information—even from other estuaries—that provides quantitative data on the path of change, before the system was degraded and then at different phases of degradation and how that relates to biomass of different kinds of algae. Just because we see the pattern over and over again there isn't a lot of hard quantitative data that tells us the pathway and where we're at on that pathway.

To pile on, with respect to what Art was saying. To add that type of data to the existing data sets, plotting the other known data is sometimes much more useful than error bars. If you plot other known data sets, throw all the caveats on there (it's only part of the picture), but it's essential for us to better understand our data set in terms of the larger body of literature. If you don't have the larger context of the body of knowledge we are missing something.

Rob Roseen: To pile on, with respect to what Art was saying…To add that data from the literature to the existing data sets is sometimes much more useful than error bars. If you plot other known datasets, and then include all the caveats in there (e.g., it's only part of the picture), that helps us to better understand our dataset. If you don't have the larger context of the body of knowledge, we are missing something.

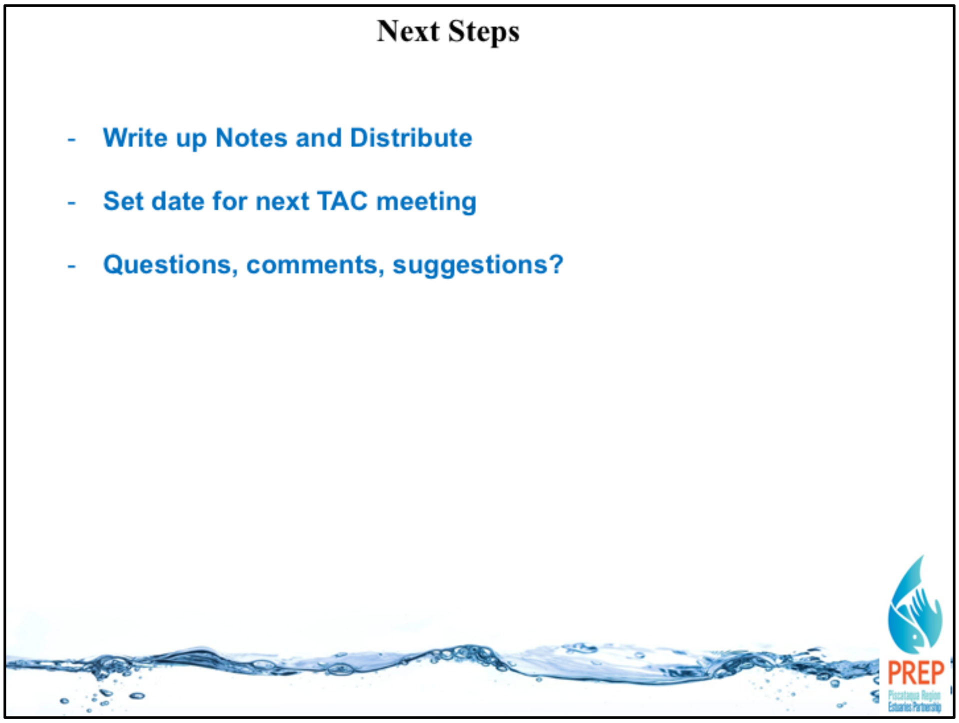
Review

- Biomass, 1996, Epiphytes
- Our interpretation of the Peer Review with regard to nitrogen and eelgrass
- Review of eelgrass graphs from 2012 Data Report
- Subtidal Macroalgae and SeagrassNet
- Intertidal Macroalgae: potential ways of showing data

PREP

Piscataqua Region Estuaries Partnership

Kalle: Reviewing the topics that were covered today.



Kalle: We’ll send these slides and notes out and soon we’ll set anotiher date for the next TAC meeting. Right now, we’re thinking of something in mid-December.

Thank you all very much for your time.